Title: Changes in method specific suicide following a national pesticide ban in India (2011-2014)

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Abstract

Background: This paper investigates whether declines in suicide by insecticide poisoning in India following a national ban on endosulfan in 2011were associated with changes in other methods of suicide and total suicide rates.

Method: Method-specific suicide rates between 2001-2014 were calculated using National Crime Records Bureau (NCRB) data by sex, age group and region, with observed rates compared to expected rates for the period post-2011.

Results: There were an estimated 20,146 fewer male and 8,418 fewer female suicides by insecticide poisoning and 5542 fewer male and 2679 fewer female suicides by all other methods following the national endosulfan ban. Contemporaneously, an estimated 92% (23,812) of male and 60% (6,735) of female suicides prevented by insecticide poisoning and all other methods were offset to increases in suicides by hanging and other poisoning. Joinpoint regression indicated a decrease in suicide by insecticide poisoning following the endosulfan ban (annual percentage change (APC) of -12.18 among males and -11.89 among females between 2010-2014) while an increase in male suicide by hanging was noted between 2009-2014 (APC of 7.05).

Limitation: Suicide rates based on the NCRB data might be an underestimation of the true suicide rates.

Conclusion: Declines in suicide by insecticide poisoning were largely offset by an increase in hanging suicides among males, however, this phenomenon was much less prominent in females and contributed to declines in total female suicide rates. Prevention strategies must continue to focus on pesticide bans with simultaneous attention on hanging prevention policies to reduce overall suicide rates in India.

Keywords: Suicide, Hanging, Insecticide poisoning, Method substitution, India

Introduction

India has reported high suicide rates over the past few decades (Arya et al., 2018; India State-Level Disease Burden Initiative Suicide Collaborators, 2018). While male suicide rates have remained relatively stable, female suicide rates have shown a downward trend in recent years (Arya et al., 2018; India State-Level Disease Burden Initiative Suicide Collaborators, 2018). In 2016, there were more than 200,000 suicides in India, with an estimated contribution to 25% of male and 37% of female suicides globally (India State-Level Disease Burden Initiative Suicide Collaborators, 2018). The development and implementation of national and regional level suicide prevention measures have subsequently been suggested to counter this important public health priority in India (Arya et al., 2018; India State-Level Disease Burden Initiative Suicide Collaborators, 2018; Armstrong and Vijayakumar, 2018). Available evidence suggests that restricting access to lethal suicide means is among the most effective suicide prevention strategies (Mann et al., 2005).

Suicide by hanging is the most common method of suicide in India followed by suicide by insecticide poisoning, with the two methods accounting for 54% of male suicides and 47% of female suicides between 2001 to 2014 (Arya et al., 2019). Suicide by hanging in India has increased substantially since 2001, especially among males (Arya et al., 2019). A national ban on endosulfan (a commonly available pesticide) in 2011, was followed by falls in insecticide poisoning in 2011-2014, but rises in suicide by hanging may have offset these reductions and overall suicide rates have remained relatively stable (Bonvoisin et al., 2020).

A previous study has investigated the contemporaneous association between the endosulfan ban and changes in suicide by insecticide poisoning (Bonvoisin et al., 2020). However, the impact of the ban on other methods of suicide (e.g. offset of the ban impact by rises in other suicide methods), has not been considered, particularly in those states where almost 90% of suicides are by insecticide poisoning (Bonvoisin et al., 2020). This is important as the impact of the endosulfan ban, perhaps leading to substantial reductions in suicide by insecticide poisoning, may not have resulted in declines in the total suicide rate if there were corresponding increases in other methods. Accordingly, this study estimated the expected number of suicides by insecticide poisoning during the period 2011-2014 had there not been a ban on endosulfan, and compared this with changes in the number of suicides by hanging, other poisoning and other methods for a similar period. The study aimed to determine whether decreases in suicide by insecticide poisoning were offset by increases in suicide by other methods.

Method

Data

In the absence of a reliable civil registration system (Dandona et al., 2017), the National Crime Records Bureau (NCRB) is the only source of regularly reported and freely available suicide data in India (NCRB, 2001-2014). The NCRB, is the Indian organization which collects and publishes suicide data from each state and union territory of India based on police reports (NCRB, 2001-2014). Ecological time trend analysis of method-specific suicide rates between 2001-2014 were calculated with method specific suicide counts stratified by sex, state, age-group (15-29 years, 30-44 years, 45-59 years and ≥60) and year obtained from the NCRB website and corresponding population data extracted from the Census of India website for 2001 and 2011 (intercensal population estimates were calculated by weighted interpolation) (NCRB, 2001-2014; Census of India, 2001; Census of India, 2011). The latest NCRB data from the years 2015 and 2016 were not included in the main analysis as they did not provide suicide method counts by different age groups to allow for adjustment of important age-specific differences in suicide rate. The 2015 data also suggests misclassification of insecticide poisoning suicide as 'other poisoning' suicide ('insecticide poisoning' suicides sharp upward trend coincides with a sharp downward trend in 'other poisoning' suicides (Arya et al., 2019). Among the 16 different suicide method categories provided by the NCRB, 'hanging', 'insecticide poisoning' and 'other poisoning' were categorized separately while the remaining methods were categorized as 'all other methods'. Based on a previous study investigating the association between the national ban on endosulfan and suicide by insecticide poisoning (Bonvoisin et al., 2020), Indian states were categorized as (i) states accounting for most of India's suicides by insecticide poisoning (a group of 11 states accounting for 90.4% of India's insecticide poisoning suicides and 82.7% of total number of suicides in India between 2001-2014), and (ii) all remaining states (Web Appendix 1).

Analysis

Age standardized suicides rates (using the 2011 census population as the standard) by hanging, insecticide poisoning, other poisoning, and all other methods were calculated for each year (2001-2014) stratified by sex and the two defined geographic categories. The national endosulfan ban came into effect between January-May, 2011. Accordingly, the linear trend in method-specific suicide rates based on the 2001-2010 period was used to estimate the expected method specific suicide rates for the period 2011-2014 assuming no national endosulfan ban and that trends for the previous period 2001-2010 would continue for the period 2011-2014. The difference

between the observed and the expected rates of suicides were then calculated for 2011-2014, to ascertain whether the number of suicides by insecticide poisoning potentially averted due to the endosulfan ban was equivalent to the number of additional suicides by hanging, other poisoning and other methods that otherwise would have been expected (based on trends for the previous period). Observed and expected age specific rates, by sex and region were also calculated to investigate differences in method-specific suicide among different age groups (Web Appendix 2-5).

Joinpoint regression analysis was also conducted to empirically identify joinpoints of continuous change in trends among different suicide methods between 2001-2014 by sex and region (Kim et al., 2000). Analyses used the grid-search function, which assumes unknown joinpoints, constant variance and uncorrelated errors, with the number of significant joinpoints identified following several permutation tests (4499 tests per model) to ensure model convergence (Kim et al., 2000). Out of the three models generated for each suicide method (i.e. hanging, insecticide poisoning, other poisoning and all other methods) with 0,1 or 2 joinpoints, the best fitting model based on the mean squared error was selected. Additionally, linear regression analysis was conducted with the year 2011 specified *a* priori to identify whether trends differed following the national endosulfan ban among different suicide methods. Analyses were conducted in MS Excel, STATA 15.1 using the *mkspline* function, and Joinpoint Regression Program (Mitchell, 2008; Joinpoint Regression Program, 2019).

Results

Observed rates of male suicide by hanging increased in the period after 2011, with contemporaneous declines in suicides by insecticide poisoning. However, relatively smaller increases and decreases were evident in suicide by other poisoning and suicide by all other methods respectively (Figure 1). These patterns were much more evident among states with the highest rates of suicide by insecticide poisoning compared to remaining states (Figure 1). However, among females, the increase in suicide by hanging and suicide by other poisoning was much less evident (Figure 1).

Throughout India, there were an estimated 20,146 fewer male suicides and 8,418 fewer female suicides by insecticide poisoning, and an estimated 5542 fewer male suicides and 2679 fewer female suicide by all other methods, in the period after the endosulfan ban than expected based on previous trends (Table 1 and Table 2). Over the same period, among males, there were an estimated 16,325 additional suicides by hanging than

expected, and an estimated 7487 additional suicides by other poisoning than expected, based on previous trends (Table 1). Among females, following the endosulfan ban, there were an estimated 2,822 additional suicides by hanging than expected, and an estimated 3913 additional suicides by other poisoning than expected (Table 2).

In the context of stable overall suicide rates in India, this implies that among males, 63% (16,325 of 25,688) of the fall in suicide by insecticide poisoning and all other methods were offset by rises in suicides by hanging while 29% (7487 of 25,688) were offset by rises in suicide by other poisoning (Table 1; Figure 1). However, among females, only 25% (2,822 of 11,097) of the decrease in suicides by insecticides and all other methods were offset by rises in suicide by hanging, and 35% (3913 of 8,418) were offset by rises in other poisoning (Table 2; Figure 1). This occurred in the context of an overall downward trend among female suicides for all methods.

The divergent trend in male suicide by hanging and by insecticide poisoning in the period 2011-2014 was more marked among states where the predominant method of suicide was by insecticide poisoning (Figure 1) and also among those aged 15-29 years (Web Appendix 2-5). In the context of stable overall suicide rates in these states, this implies that 57% (12,055 of 21,123) of suicides by hanging and 36% (7,643 of 21,123) of suicides by other poisoning among males were offset from reductions in suicide by insecticide poisoning and all other methods. Differences between observed and expected hanging suicides were smaller in these states for females (18%, or 1,560 of 8,398) for suicides by hanging, but higher for suicide by other poisoning (50%, or 4243 of 8,398). Similar to all India, these trends occurred in the context of an overall downward trend in female suicide for all methods (Figure 1). There was little evidence of contemporaneous changes in rates in the remaining Indian states in the period following the endosulfan ban (Figure 1; Table 1 and Table 2).

Joinpoint regression analyses found evidence of decrease in suicide by insecticide poisoning among both sexes post the endosulfan ban in 2011 (Figure 2). There was contemporaneous rises in suicide by hanging among males, however, there was also a rise in hanging rates in the period prior to the ban (Figure 2; Table 3). This increasing trend in suicide by hanging among males in India was observed for two time periods; 2001-2006 (Annual percentage change (APC) of 4.1 (95% CI 1.6-6.7)) and 2009-2014 (APC of 7.0 (95% CI 5.4-8.8)). Suicide by insecticide poisoning decreased between 2010-2014 (APC of -12.1 (95% CI -18.4-(-5.5)). Among females in India, suicide by hanging increased across the study period (APC of 1.5 (95% CI (0.8-2.2)), while

suicide by insecticide poisoning decreased between 2001-2010 (APC of -1.3 (95% CI (-2.5-(-0.1))), with the rate of fall accelerating in 2010-2014 (APC of -11.9 (95% CI (-18.5-(-4.8))). There were also declines in suicide from all other methods among females (2001-2004=APC of 6.3 (95% CI (-10.8-(-1.8)), 2011-2014= APC of -4.9 (95% CI (-8.4-(-1.3)), but not among males. There was no statistical evidence of an increase in other poisoning suicides following the national endosulfan ban.

These patterns were similar among states with the highest rates of suicide by insecticide poisoning (Figure 2). Among different age groups, there were usually significant declines in APC's for insecticide poisoning following the endosulfan ban among all age groups for both sexes. However, APC increases for hanging were greater among the youngest age group (15-29 years) compared to older age groups, especially among females, where a significant increase in hanging was only evident among those aged 15-29 years (Web Appendix 6).

Segmented linear regression analysis of method specific suicides (based on comparisons pre-2011 and post-2011) were largely consistent with joinpoint analyses, with statistical evidence of a decrease in suicide by insecticide poisoning post-2011 evident among both sexes, and an increase in suicide by hanging suicides among males in the same period (Web Appendix 7).

Discussion

The start of a major decline in suicide by insecticide poisoning from 2011, coincided with a national ban on the class I pesticide endosulfan (January-May, 2011), suggesting a positive impact of endosulfan restriction on insecticide poisoning suicides. During the same period (2011-2014), increases in suicide by hanging and other poisoning suicides appear to have offset declines in suicide by insecticide poisoning and all other methods in males and to a lesser extent in females. These divergent trends occurred in the context of stable total suicide rates for India among males, and were much more prominent in states where the predominant method of suicide was by insecticide poisoning.

However, while the contemporaneous rise in suicide by hanging following the 2011 endosulfan ban, especially among males, is suggestive of possible substitution, it is important to note that this occurred in the context of rising trends in suicide by hanging in the period prior to this ban. Also, studies have suggested that method substitution is more gradual and associated with use of similar methods (e.g. poisoning by less hazardous

substances) in the shorter term. For example, in Sri Lanka, falls in suicide by pesticide poisoning were accompanied by rises in the incidence of suicide by hanging, but the magnitude of the fall in pesticide suicides was far greater than the rise in hanging and so the latter trends had little impact on overall suicide rates (Knipe et al., 2014). Similarly, in other countries where the impact of pesticide bans has been evaluated, little change in the incidence of suicide by other methods has been seen (Cha et al., 2016; Chowdhury et al., 2018). Indeed, it is likely that the ban of one toxic pesticide is likely to result in individuals simply ingesting an alternative (less toxic) pesticide, thereby reducing the case fatality, rather than the overall incidence of pesticide ingestion. For example, in Sri Lanka, the incidence of (largely non-fatal) pesticide self-poisoning rose over the period that pesticide suicides declined (Gunnell et al., 2007). There is some evidence of increase in other poisoning suicides following the endosulfan ban in India, especially among females, which suggests the use of alternate poisoning methods. However, the increase in other poisoning suicides was not found to be significant. Furthermore, it has been suggested that individuals are less likely to attempt suicide if the preferred method is not available (Yip et al., 2012), decreasing the likelihood of method substitution.

In India, the prominent rise in suicide by hanging among males following the endosulfan ban and in the previous periods, might be explained through the cultural significance of hanging coupled with over reporting of suicide by hanging in the media (i.e. indirect "promotion" of this method) (Thakur 1963; Armstrong et al., 2019). Furthermore, the rise in hanging suicides in India might also be reflective of an overall increase in urban suicides and increasing urban migration from rural areas in India (Deshingkar and Sandi, 2011).

Increases in suicide by hanging offset most of the countrywide declines in male suicides by insecticide poisoning post-2011. However, the proportion of suicides offset by hanging was lower among states where insecticide poisoning was the prominent method of suicide. Insecticide poisoning suicides are more likely to occur in rural areas where improvised dwellings are common, and unsuitable for hanging suicides (Parkar et al., 2009; Joshi et al., 2015), which might explain the lower proportion of suicides substituted by hanging and a higher proportion by other poisoning in these states. However, while indoor suicides at residential sites are usually more common in India (Mohanty et al., 2007; Ambade et al., 2007; Gururaj and Issac, 2001), it might also be argued that hanging can easily be completed outdoors, especially in rural areas (e.g. using trees). More information on modes of suicide by hanging (in particular an understanding of ligature points used) might help us ascertain the reasons for this disparity.

The largest annual percentage change in hanging was observed among those aged 15-29 years, particularly for females. Among males, the increase in suicides by hanging outnumbered the decrease in suicide by insecticide poisoning in the 15-29 and ≥60 age groups. This likely represents a higher prevalence of hanging as a choice of suicide method compared to insecticide poisoning among these age groups. Among females, increase in hanging was only observed among the youngest age-group possibly because of the general preference among females to use less violent suicide methods (Ajdacic-Gross et al., 2008).

There are some limitations of this study. Firstly, the observed rates are likely an under-estimate of actual rates as the NCRB data has previously been shown to under-enumerate suicides cases in India, due to social and legal repercussions attached with suicidal behavior in India (Vijayakumar, 2007; Patel et al., 2012; Vijayakumar et al., 2020). Secondly, the populations were derived from two census years with inter-censal years interpolated, perhaps under-estimating any underlying non-linear trends in population. Thirdly, there might be some misclassification of insecticide poisoning suicide as 'other poisoning' suicide in the NCRB data. Fourthly, the expected suicide rate calculations are based on the assumption that suicide rates by different methods would follow a consistent linear trend in the period after the endosulfan ban, potentially under-estimating any non-linear trends unrelated to the ban. However, this linear assumption appears not unreasonable given the relatively stable (linear) trends in the period 2001-2010 for both males and females, and for the two defined geographic regions.

The findings of this study support the notion that the national endosulfan ban resulted in substantial declines in suicide by insecticide poisoning in India. However, among males, suicide rates have not changed substantially, largely due to increases in suicide by hanging. This highlights that whilst means restriction strategies focusing on frequently used, high lethality methods may result in reductions in overall suicide rates, such reductions may be offset by rises in the use of other methods. In the UK, for example, whilst de-toxication of the domestic gas supply in the 1960s resulted in falls in suicide by this method, a subsequent rise in suicide by carbon monoxide poisoning using motor vehicle exhaust gas by young men offset some of these gains (Thomas and Gunnell, 2010). It is essential that policy makers remain vigilant to the emergence of new methods of suicide in order, if possible, to implement means prevention strategies (Thomas et al., 2011). Suicide by hanging is known to be difficult to prevent due to the presence of ligature points and ligature materials in regular surroundings (Gunnell et al., 2005). However, the growing number of hanging suicides in India highlight the need for collective effort

including via media (e.g. reductions in fictional portrayal of hanging suicides), newspaper (e.g. non graphic and non-descriptive reporting of suicides) and the implementation of novel strategies (for example spring fitted ceiling fans in controlled environments such as student hostels), to address the increasing trends in suicide by hanging (Gunnell et al., 2005; Biddle et al., 2010; Niederkrotenthaler et al., 2014; Armstrong et al., 2018; Mishra et al., 2019), and to build upon the gains from the restriction of access to pesticides, to ensure that overall suicide rates in India also are reduced.

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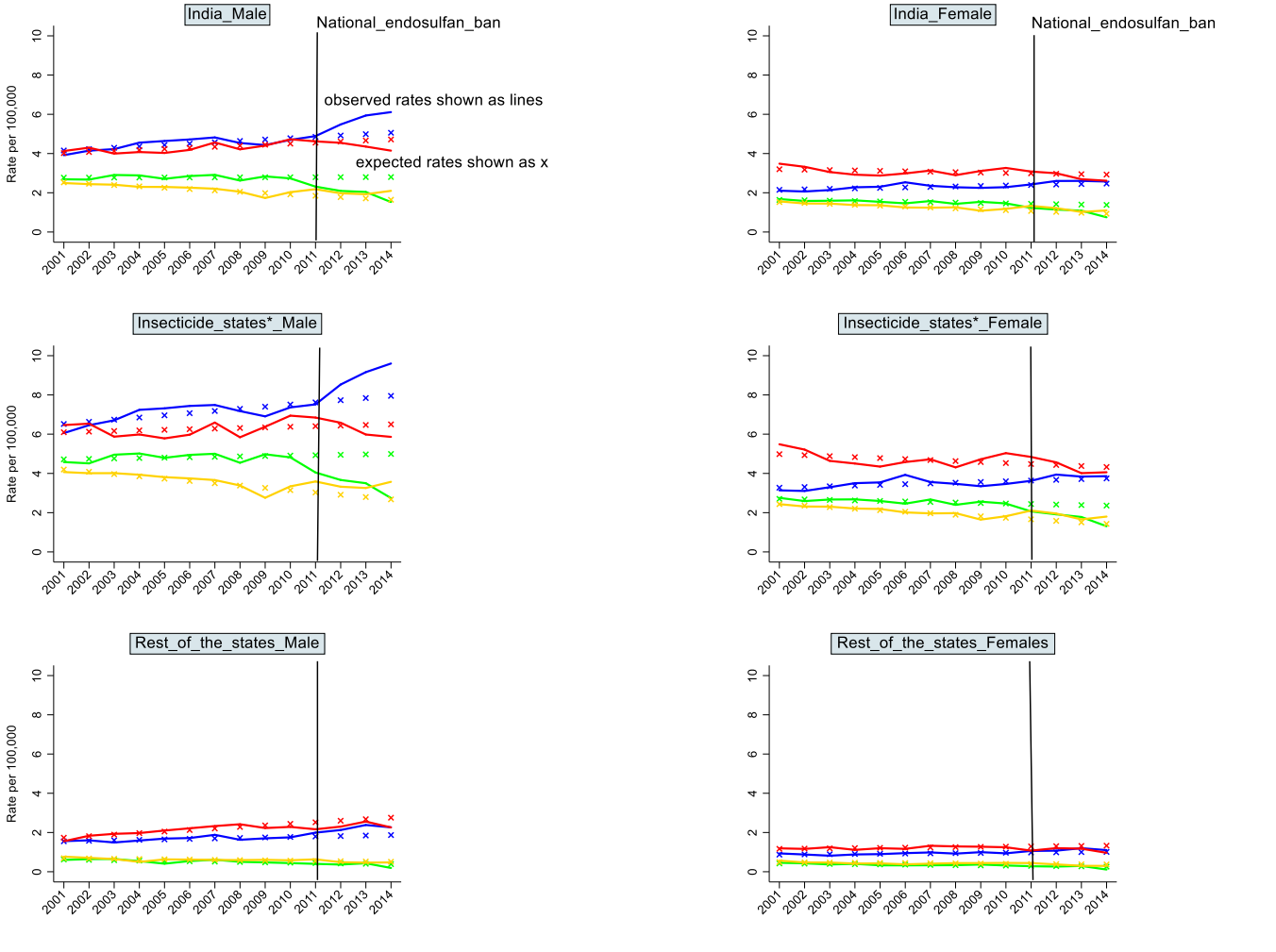
Figure 1: Observed and expected (based on linear trend forecasting) suicides rates in India between 2001-2014 by methods, sex, and region



obs: observed; exp: expected

***Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Table 1: Observed and expected (based on linear trend forecasting) suicides rates, rate differences and count differences in India between 2001-2014 by different suicide methods and region: Male

Year	India				Insecticide states*				Rest of the states			
Hanging	**Rate observed**	**Rate expected**	**Rate difference**	**Count difference**	**Rate observed**	**Rate expected**	**Rate difference**	**Count difference**	**Rate observed**	**Rate expected**	**Rate difference**	**Count difference**
2011	4.89 (4.84-4.95)	4.85 (4.8-4.91)	0.04	246	7.51 (7.43-7.61)	7.62 (7.53-7.72)	-0.11	-338	1.99 (1.94-2.04)	1.79 (1.75-1.85)	0.2	584
2012	5.48 (5.43-5.54)	4.92 (4.87-4.98)	0.56	3532	8.53 (8.43-8.63)	7.73 (7.64-7.83)	0.8	2625	2.12 (2.07-2.18)	1.82 (1.77-1.87)	0.3	908
2013	5.93 (5.88-6)	4.99 (4.94-5.05)	0.94	5947	9.16 (9.06-9.27)	7.84 (7.75-7.94)	1.32	4343	2.38 (2.33-2.44)	1.84 (1.8-1.9)	0.54	1604
2014	6.11 (6.04-6.16)	5.06 (5-5.12)	1.05	6600	9.6 (9.5-9.71)	7.95 (7.86-8.05)	1.65	5425	2.26 (2.21-2.32)	1.87 (1.82-1.92)	0.39	1175
Total	**5.6 (5.58-5.64)**	**4.95 (4.93-4.98)**	**0.65**	**16325**	**8.7 (8.65-8.76)**	**7.78 (7.74-7.84)**	**0.92**	**12055**	**2.19 (2.17-2.22)**	**1.83 (1.81-1.86)**	**0.36**	**4270**
Insecticide Poisoning												
2011	2.31 (2.28-2.35)	2.79 (2.75-2.84)	-0.48	-3017	4.04 (3.98-4.12)	4.92 (4.85-5.01)	-0.88	-2901	0.4 (0.38-0.42)	0.44 (0.42-0.46)	-0.04	-116
2012	2.09 (2.06-2.13)	2.79 (2.76-2.84)	-0.7	-4403	3.66 (3.6-3.73)	4.95 (4.88-5.03)	-1.29	-4229	0.36 (0.34-0.38)	0.42 (0.4-0.44)	-0.06	-173
2013	2.04 (2.01-2.08)	2.79 (2.76-2.84)	-0.75	-4751	3.5 (3.44-3.57)	4.97 (4.9-5.05)	-1.47	-4836	0.43 (0.41-0.45)	0.4 (0.38-0.43)	0.03	84
2014	1.53 (1.5-1.56)	2.8 (2.76-2.84)	-1.27	-7976	2.74 (2.69-2.8)	4.99 (4.92-5.07)	-2.25	-7393	0.19 (0.17-0.21)	0.38 (0.36-0.41)	-0.19	-582
Total	**1.99 (1.98-2.01)**	**2.79 (2.78-2.82)**	**-0.8**	**-20146**	**3.48 (3.46-3.52)**	**4.96 (4.92-5.0)**	**-1.48**	**-19359**	**0.34 (0.33-0.36)**	**0.41 (0.40-0.42)**	**-0.07**	**-787**
Other Poisoning												
2011	2.18 (2.15-2.22)	1.85 (1.82-1.88)	0.33	2088	3.58 (3.52-3.65)	3.02 (2.97-3.09)	0.56	1838	0.63 (0.6-0.64)	0.55 (0.52-0.57)	0.08	249
2012	1.97 (1.94-2.01)	1.78 (1.75-1.82)	0.19	1208	3.32 (3.26-3.39)	2.91 (2.85-2.97)	0.41	1350	0.48 (0.46-0.51)	0.53 (0.51-0.56)	0.05	-142
2013	1.92 (1.89-1.96)	1.71 (1.68-1.75)	0.21	1346	3.25 (3.19-3.32)	2.79 (2.74-2.85)	0.46	1515	0.46 (0.44-0.49)	0.52 (0.49-0.54)	-0.06	-168
2014	2.09 (2.06-2.14)	1.64 (1.61-1.68)	0.45	2843	3.57 (3.51-3.64)	2.67 (2.62-2.73)	0.9	2940	0.47 (0.45-0.5)	0.5 (0.48-0.53)	-0.03	-95
Total	**2.04 (2.03-2.06)**	**1.74 (1.73-1.76)**	**0.3**	**7487**	**3.43 (3.4-3.47)**	**2.85 (2.83-2.88)**	**0.58**	**7643**	**0.51 (0.5-0.53)**	**0.53 (0.51-0.54)**	**-0.02**	**-156**
All other methods												
2011	4.62 (4.57-4.67)	4.55 (4.51-4.61)	0.07	389	6.84 (6.76-6.94)	6.4 (6.32-6.49)	0.44	1448	2.16 (2.11-2.22)	2.52 (2.46-2.58)	-0.36	-1060
2012	4.54 (4.49-4.6)	4.61 (4.56-4.67)	-0.07	-410	6.58 (6.5-6.68)	6.43 (6.35-6.53)	0.15	481	2.3 (2.25-2.36)	2.59 (2.54-2.66)	-0.29	-887
2013	4.35 (4.3-4.41)	4.66 (4.61-4.72)	-0.31	-1943	5.98 (5.9-6.07)	6.46 (6.38-6.56)	-0.48	-1596	2.56 (2.5-2.62)	2.67 (2.62-2.74)	-0.11	-350
2014	4.14 (4.1-4.2)	4.71 (4.67-4.77)	-0.57	-3578	5.86 (5.78-5.95)	6.5 (6.41-6.59)	-0.64	-2098	2.26 (2.21-2.31)	2.75 (2.7-2.82)	-0.49	-1480
Total	**4.41 (4.39-4.44)**	**4.63 (4.61-4.67)**	**-0.22**	**-5542**	**6.31 (6.28-6.36)**	**6.45 (6.41-6.5)**	**-0.14**	**-1764**	**2.32 (2.29-2.35)**	**2.63 (2.61-2.67)**	**-0.31**	**-3778**

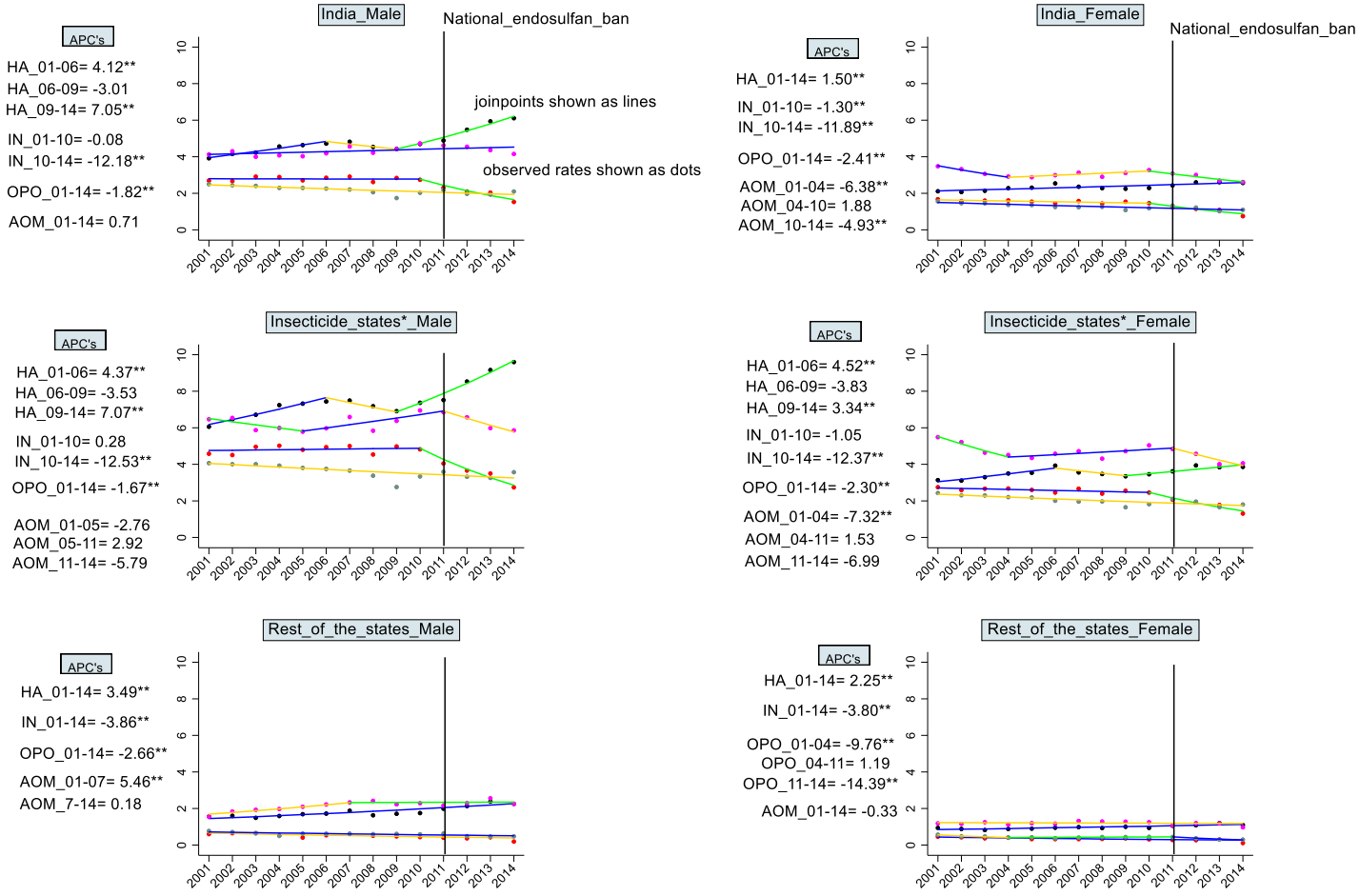
*** Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Table 2: Observed and expected (based on linear trend forecasting) suicides rates, rate differences and count differences in India between 2001-2014 by different suicide methods and region: Female

Year	India				Insecticide states*				Rest of the states			
Hanging	**Rate observed**	**Rate expected**	**Rate difference**	**Count difference**	**Rate observed**	**Rate expected**	**Rate difference**	**Count difference**	**Rate observed**	**Rate expected**	**Rate difference**	**Count difference**
2011	2.42 (2.39-2.47)	2.39 (2.36-2.44)	0.03	178	3.62 (3.56-3.69)	3.63 (3.57-3.7)	-0.01	-47	1.06 (1.02-1.1)	0.98 (0.94-1.02)	0.08	223
2012	2.6 (2.56-2.64)	2.42 (2.38-2.46)	0.18	1070	3.94 (3.87-4.01)	3.67 (3.61-3.74)	0.27	842	1.07 (1.04-1.11)	0.99 (0.95-1.03)	0.08	233
2013	2.6 (2.57-2.65)	2.44 (2.41-2.49)	0.16	955	3.83 (3.77-3.91)	3.7 (3.64-3.78)	0.13	403	1.2 (1.16-1.24)	1 (0.96-1.04)	0.2	551
2014	2.57 (2.53-2.61)	2.47 (2.43-2.51)	0.1	619	3.86 (3.79-3.93)	3.74 (3.68-3.81)	0.12	361	1.1 (1.07-1.14)	1.01 (0.97-1.05)	0.09	254
Total	**2.55 (2.53-2.57)**	**2.43 (2.41-2.45)**	**0.12**	**2822**	**3.81 (3.78-3.85)**	**3.69 (3.66-3.73)**	**0.12**	**1560**	**1.11 (1.09-1.13)**	**0.99 (0.97-1.01)**	**0.12**	**1262**
Insecticide Poisoning												
2011	1.23 (1.2-1.26)	1.44 (1.41-1.47)	-0.21	-1224	2.06 (2.02-2.12)	2.43 (2.38-2.49)	-0.37	-1178	0.28 (0.26-0.3)	0.29 (0.27-0.32)	-0.01	-46
2012	1.14 (1.12-1.17)	1.42 (1.39-1.45)	-0.28	-1624	1.91 (1.87-1.96)	2.41 (2.36-2.47)	-0.5	-1567	0.26 (0.24-0.28)	0.28 (0.26-0.3)	-0.02	-56
2013	1.08 (1.06-1.11)	1.4 (1.37-1.43)	-0.32	-1851	1.77 (1.73-1.83)	2.38 (2.33-2.44)	-0.61	-1913	0.29 (0.27-0.31)	0.27 (0.25-0.29)	0.02	62
2014	0.75 (0.73-0.77)	1.38 (1.35-1.41)	-0.63	-3719	1.3 (1.27-1.35)	2.36 (2.31-2.41)	-1.06	-3312	0.11 (0.1-0.12)	0.26 (0.24-0.28)	-0.37	-407
Total	**1.05 (1.04-1.07)**	**1.42 (1.40-1.43)**	**-0.37**	**-8418**	**1.76 (1.74-1.79)**	**2.39 (2.37-2.43)**	**-0.63**	**-7970**	**0.24 (0.23-0.25)**	**0.28 (0.27-2.90)**	**-0.04**	**-448**
Other Poisoning												
2011	1.33 (1.3-1.36)	1.07 (1.04-1.1)	0.26	1535	2.1 (2.06-2.16)	1.66 (1.62-1.71)	0.44	1410	0.44 (0.42-0.47)	0.39 (0.37-0.42)	0.05	126
2012	1.21 (1.19-1.25)	1.02 (1-1.05)	0.19	1135	1.95 (1.91-2.01)	1.58 (1.54-1.63)	0.37	1177	0.37 (0.34-0.38)	0.38 (0.36-0.41)	-0.01	-42
2013	1.02 (1-1.05)	0.97 (0.95-1.01)	0.05	261	1.65 (1.61-1.7)	1.5 (1.46-1.55)	0.15	475	0.3 (0.28-0.32)	0.38 (0.35-0.4)	-0.08	-215
2014	1.1 (1.07-1.13)	0.93 (0.9-0.96)	0.17	982	1.8 (1.76-1.85)	1.42 (1.39-1.47)	0.38	1179	0.29 (0.27-0.32)	0.37 (0.34-0.39)	-0.08	-199
Total	**1.16 (1.15-1.18)**	**1.01 (1-1.02)**	**0.15**	**3913**	**1.88 (1.86-1.9)**	**1.54 (1.52-1.57)**	**0.34**	**4243**	**0.35 (0.34-0.36)**	**0.38 (0.37-0.39)**	**-0.03**	**-330**
All other methods												
2011	3.08 (3.04-3.13)	2.99 (2.95-3.04)	0.09	542	4.84 (4.76-4.92)	4.47 (4.41-4.55)	0.37	1136	1.07 (1.04-1.12)	1.29 (1.25-1.33)	-0.22	-591
2012	2.99 (2.95-3.04)	2.97 (2.93-3.01)	0.02	154	4.56 (4.49-4.64)	4.42 (4.36-4.5)	0.14	430	1.2 (1.16-1.25)	1.3 (1.26-1.35)	-0.1	-277
2013	2.69 (2.65-2.73)	2.94 (2.91-2.99)	-0.25	-1530	4.01 (3.94-4.08)	4.37 (4.31-4.45)	-0.36	-1149	1.17 (1.14-1.22)	1.31 (1.27-1.36)	-0.14	-382
2014	2.61 (2.57-2.66)	2.92 (2.89-2.97)	-0.31	-1845	4.05 (3.99-4.13)	4.32 (4.26-4.4)	-0.27	-847	0.96 (0.93-1)	1.32 (1.29-1.37)	-0.36	-999
Total	**2.84 (2.82-2.87)**	**2.96 (2.94-2.98)**	**-0.12**	**-2679**	**4.37 (4.33-4.41)**	**4.4 (4.37-4.44)**	**-0.03**	**-428**	**1.1 (1.09-1.13)**	**1.31 (1.29-1.33)**	**-0.21**	**-2251**

*** Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Figure 2: Joinpoint regression analysis of suicide rates and time period by different suicide methods, sex, and region, 2001-2014



HA: Hanging; IN: Insecticide; OPO: Other poisoning; AOM: All other methods

**APC significantly different from zero at alpha= 0.05 level

***Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**
APC's= Annual Percentage Changes

Table 3: Joinpoint regression analysis of suicide rates (with 95% confidence intervals) and time period by different suicide methods, sex, and region, 2001-2014

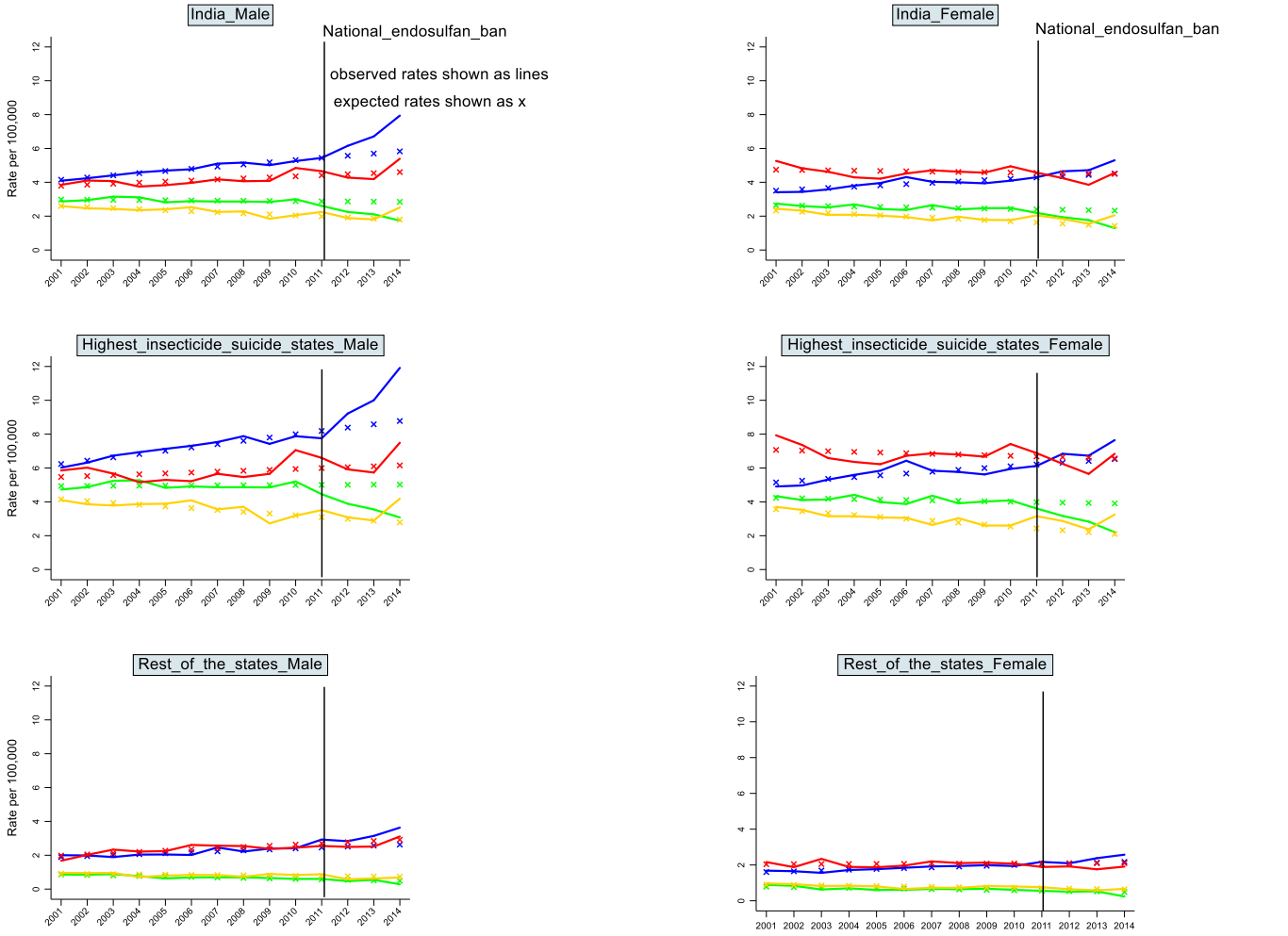
	Hanging		Insecticide poisoning		Other poisoning		All other methods
MALES							
India							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2006	4.1** (1.6-6.7)	2001-2010	-0.08 (-1.4-1.2)	2001-2014	-1.8** (-2.6-(-1.1)	2001-2014	0.7 (-0.0-1.4)
2006-2009	-3.0 (-11.3-6.1)	2010-2014	-12.1** (-18.4-(-5.5)				
2009-2014	7.0** (5.4-8.8)						
Insecticide states*							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI) ***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2006	4.4** (2.1-6.7)	2001-2010	0.2 (-0.9-1.5)	2001-2014	-1.6** (-2.5-(-0.8)	2001-2005	-2.7 (-8.2-3.0)
2006-2009	-3.5 (-11.4-5.1)	2010-2014	-12.5** (-18.6-(-6.1)			2005-2011	2.9 (-1.0-7.0)
2009-2014	7.1** (5.4-8.8)					2011-2014	-5.7 (-14.0-3.2)
Rest of the states							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2014	3.4** (2.5-4.5)	2001-2014	-3.8** (-5.7-(-2.0)	2001-2014	-2.6** (-3.9-(-1.4)	2001-2007	5.4** (1.6-9.5)
						2007-2014	0.1 (-1.9-2.3)
FEMALES							
India							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2014	1.5** (0.8-2.2)	2001-2010	-1.3** (-2.5-(-0.1)	2001-2014	-2.4** (-3.2-(-1.6)	2001-2004	-6.3** (-10.8-(-1.8)
		2010-2014	-11.8** (-18.5-(-4.8)			2004-2010	1.8 (-0.6-4.4)
						2010-2014	-4.9** (-8.4-(-1.3)
Insecticide states*							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2006	4.5** (1.7-.4)	2001-2010	-1.0 (-2.1-0.0)	2001-2014	-2.3** (-3.2-(-1.4)	2001-2004	-7.3** (-13.3-(-0.9)
2006-2009	-3.8 (-13.9-7.5)	2010-2014	-12.3** (-18.5-(-5.7)			2004-2011	1.5 (-1.0-4.1)
2009-2014	3.3** (1.0-5.8)					2011-2014	-6.9 (-14.6-(1.3)
Rest of the states							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2014	2.2** (1.4-3.1)	2001-2014	-3.8** (-5.2-(-2.4)	2001-2004	9.7** (-15.9-(-3.1)	2001-2014	-0.3 (-1.5-0.8)
				2004-2011	1.1 (-1.9-4.4)		
				2011-2014	-14.3** (-25.3-(-2.8)		

***Annual Percentage Change (APC) with 95% confidence interval**
****APC significantly different from zero at the alpha level= 0.05 level**
***** Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Web Appendix 1: 11 states with high insecticide poisoning suicides and the rest of the states

11 states with high insecticide poisoning suicides	Rest of the states
Andhra Pradesh	Arunachal Pradesh
Chhattisgarh	Assam
Gujarat	Bihar
Karnataka	Goa
Kerala	Haryana
Madhya Pradesh	Himachal Pradesh
Maharashtra	Jammu & Kashmir
Odisha	Jharkhand
Tamil Nadu	Manipur
Telangana	Meghalaya
West Bengal	Mizoram
	Nagaland
	Punjab
	Rajasthan
	Sikkim
	Tripura
	Uttar Pradesh
	Uttarakhand
	Andaman & Nicobar Islands
	Chandigarh
	Dadra & Nagar Haveli
	Daman & Diu
	Delhi
	Lakshadweep
	Puducherry

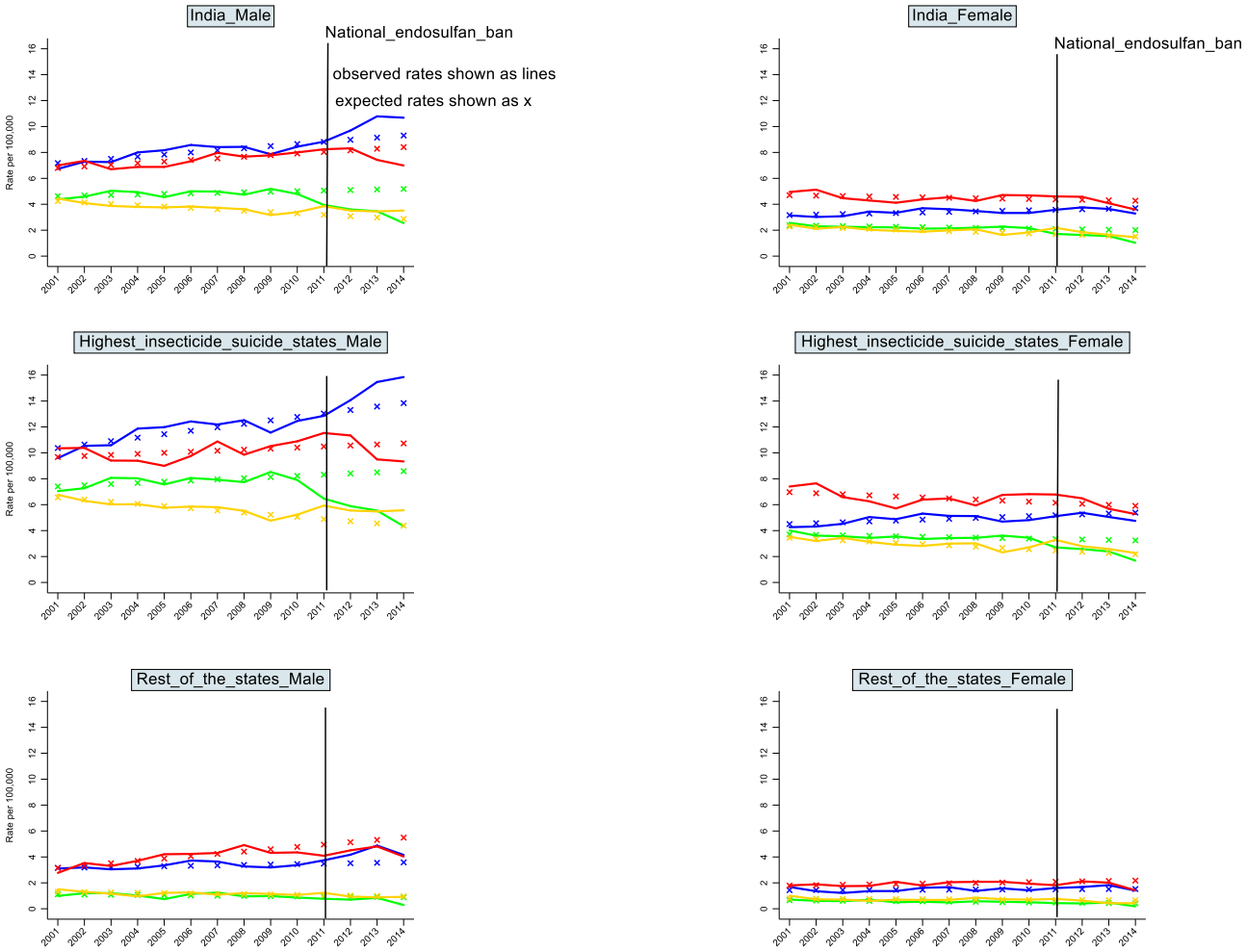
Web Appendix 2: Observed and expected suicides rates (based on linear trend forecasting) in India from 2011-2014 by different suicide methods, sex and region: 15-29 years



obs: observed; exp: expected

***Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

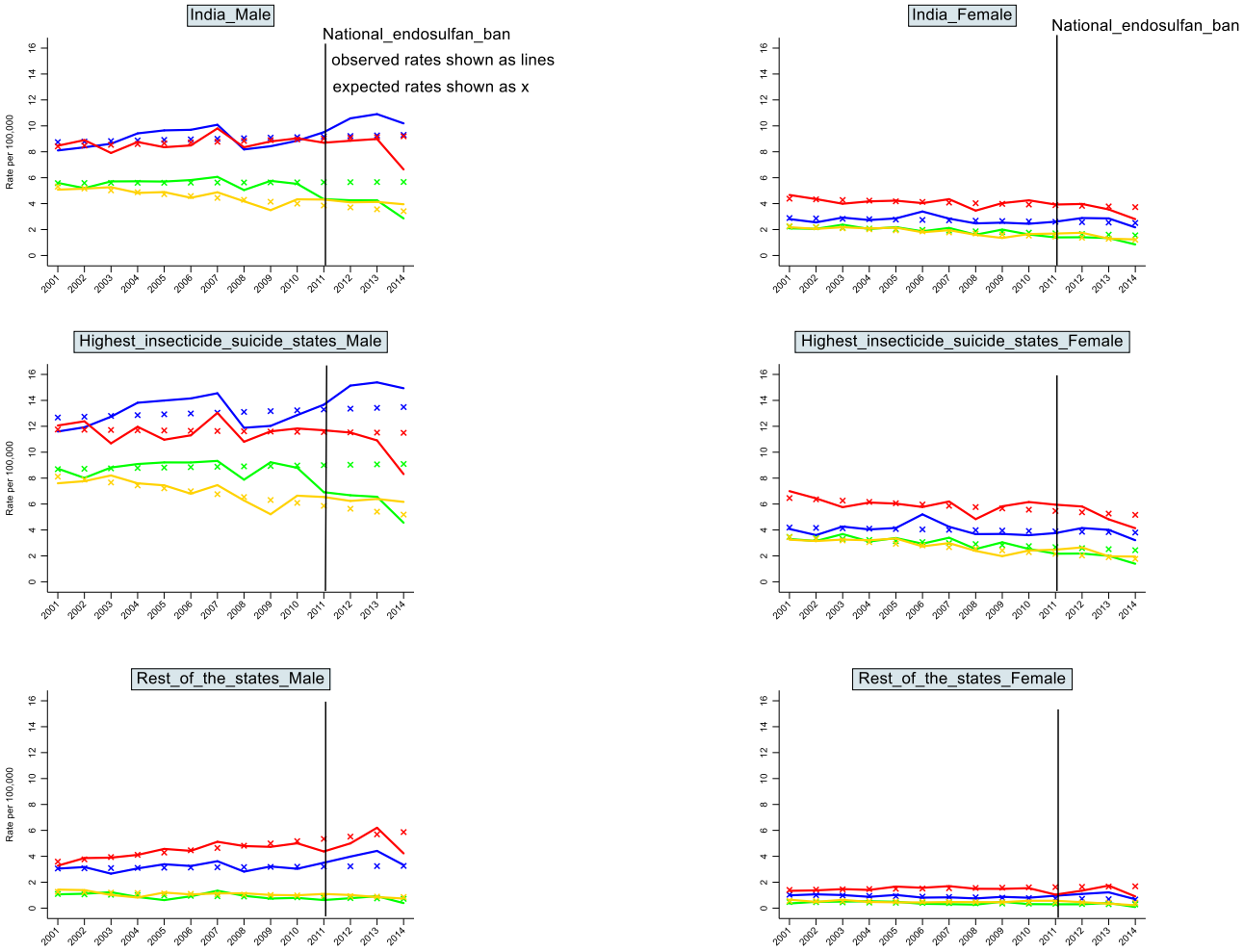
Web Appendix 3: Observed and expected suicides rates (based on linear trend forecasting) in India from 2011-2014 by different suicide methods, sex and region: 30-44 years



obs: observed; exp: expected

***Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Web Appendix 4: Observed and expected suicides rates (based on linear trend forecasting) in India from 2011-2014 by different suicide methods, sex and region: 45-59 years



obs: observed; exp: expected

***Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Web Appendix 5: Observed and expected suicides rates (based on linear trend forecasting) in India from 2011-2014 by different suicide methods, sex and region: 60 and above

obs: observed; exp: expected

***Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014**

Web Appendix 6: Joinpoint regression analysis of suicide rates (with 95% confidence intervals) and time period by different suicide methods and age-groups for India, 2001-2014

	Hanging		Insecticide Poisoning		Other Poisoning		All other methods
MALES							
15-29							
Estimated joinpoints	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***	**Estimated joinpoints**	**APC (95% CI)***
2001-2011	2.6** (1.8-3.3)	2001-2010	-0.4 (-1.5-0.8)	2001-2014	-1.3 (-2.5-0.0)	2001-2014	2.1** (1.0-3.2)
2011-2014	13.1** (10.1-16.1)	2010-2014	-11.1** (-16.4-(-5.5))				
30-44							
2001-2006	4.9** (1.4-8.6)	2001-2009	1.4 (-0.3-3.2)	2001-2014	-1.6** (-2.3-(-0.8))	2001-2012	1.8** (0.9-2.6)
2006-2009	-2.6 (-14.3-10.6)	2009-2014	-10.8** (-15.4-(-6.0))			2012-2014	-8.6 (-20.0-4.4)
2009-2014	6.6** (4.1-9.2)						
45-59							
2001-2014	1.6** (0.5-2.7)	2001-2009	0.6 (-1.7-2.9)	2001-2014	-2.2** (-3.0-(-1.4))	2001-2014	-0.0 (-1.2-1.1)
		2009-2014	-9.7** (-15.9-(-3.0))				
60 and above							
2001-2005	4.0 (-3.6-12.3)	2001-2007	2.9 (-0.3-6.2)	2001-2014	-2.4** (-4.1-(-0.6))	2001-2014	-0.6 (-1.9-0.6)
2005-2009	-6.7 (-18.8-7.2)	2007-2014	-7.7** (-11.2-(-4.1)				
2009-2014	6.3** (0.5-12.4)						
FEMALES							
15-29							
2001-2006	4.9** (2.6-7.3)	2001-2010	-0.9 (-2.2-0.4)	2001-2014	-1.9** (-3.0-(-0.7))	2001-2014	-0.8 (-1.8-0.1)
2006-2009	-2.8 (-10.9-6.0)	2010-2014	-11.7** (-18.7-(-4.1))				
2009-2014	6.1** (4.4-7.8)						
30-44							
2001-2014	0.9 (-0.0-1.8)	2001-2010	-1.4** (-2.8-(-0.0))	2001-2014	-2.1** (-3.4-(-0.8))	2001-2004	-5.9 (-12.7-1.4)
		2010-2014	-12.5** (-21.5-(-2.5))			2004-2012	1.1 (-1.1-3.3)
						2012-2014	-12.5 (-28.8-7.4)
45-59							
2001-2014	-0.7 (-2.3-0.9)	2001-2014	-3.7** (-5.6-(-1.8))	2001-2014	-3.4** (-4.7-(-2.0))	2001-2014	-1.6** (-2.7-(-0.5))
60 and above							
2001-2014	-0.3 (-1.5-1.0)	2001-2004	9.6 (-5.8-27.6)	2001-2014	-2.5** (-4.6-(-0.3))	2001-2004	-7.8 (-17.1-2.7)
		2004-2014	-4.2** (-6.6-(-1.7))			2004-2012	1.4 (-2.1-5.0)
						2012-2014	-15.0 (-40.3-21.2)

***Annual Percentage Change (APC) with 95% confidence interval**
****APC significantly different from zero at the alpha level= 0.05 level**

Web Appendix 7: Linear regression analysis of suicide rates (with 95% confidence intervals) and time period; before (2001-2010) and after the national endosulfan ban (2011-2014), by different suicide methods for India

	Hanging		Insecticide Poisoning		Other Poisoning		All other methods	
MALES								
INDIA	**β* (95% CI)****	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
2001-2010	0.07 (0.03-0.11)	0.00***	-0.02 (-0.05-0.01)	0.16	-0.05 (-0.07-(-0.02))	0.00***	0.05 (0.02-0.09)	0.00***
2011-2014	0.44 (0.29-0.59)	0.00***	-0.3 (-0.48-(-0.22))	0.00***	0.03 (-0.06-0.13)	0.48	-0.13 (-0.26-(-0.00))	0.03***
Insecticide states	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
2001-2010	0.11 (0.04-0.17)	0.00***	-0.02 (-0.08-0.03)	0.35	-0.09 (-0.14-(-0.04))	0.00***	0.05 (-0.01-0.13)	0.12
2011-2014	0.70 (0.45-0.94)	0.00***	-0.62 (-0.85-(-0.39))	0.00***	0.09 (-0.08-0.27)	0.26	-0.24 (-0.53-0.04)	0.09
Rest of the states	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
2001-2010	0.03 (0.01-0.06)	0.00***	-0.01 (-0.03-(-0.00))	0.01***	-0.01 (-0.02-0.00)	0.05	0.06 (0.03-0.09)	0.00***
2011-2014	0.16 (0.08-0.25)	0.00***	-0.05 (-0.11-(-0.00))	0.03***	-0.03 (-0.08-0.00)	0.08	-0.01 (-0.13-0.10)	0.75
FEMALES								
INDIA	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
2001-2010	0.02 (0.00-0.05)	0.01***	-0.02 (-0.04-(-0.01))	0.00***	-0.03 (-0.04-(-0.01))	0.00***	-0.01 (-0.05-0.02)	0.38
2011-2014	0.06 (-0.01-0.15)	0.10	-0.19 (-0.25-(-0.13))	0.00***	-0.02 (-0.09-0.03)	0.34	-0.14 (-0.27-(0.00))	0.04***
Insecticide states	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
2001-2010	0.04(0.00-0.08)	0.04***	-0.04 (-0.06-(-0.01))	0.00***	-0.05 (-0.08-(-0.02))	0.00***	-0.03 (-0.09-0.03)	0.32
2011-2014	0.08 (-0.06-0.23)	0.25	-0.32 (-0.41-(-0.22))	0.00***	-0.01 (-0.12-0.09)	0.72	-0.20 (-0.46-0.05)	0.10
Rest of the states	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
2001-2010	0.01 (0.00-0.02)	0.00***	-0.01 (-0.02-(-0.00))	0.00***	-0.00 (-0.01-0.00)	0.07	0.00 (-0.01-0.02)	0.51
2011-2014	0.04 (0.00-0.09)	0.02***	-0.04 (-0.07-(-0.01))	0.01***	-0.04 (-0.07-(-0.01))	0.01***	-0.06 (-0.13-(-0.00))	0.02***

***The standardised Beta coefficient (β) denotes the Beta value where Beta is the rate increase on the Y axis (method specific suicide rates) when there is a one percent rate increase on the X axis (time period).**

**** 95% confidence interval**

*****β significantly different from zero at the alpha level= 0.05 level**

Insecticide states are a group of 11 states (Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, West Bengal) accounting for 90.4% of India's insecticide poisoning suicides between 2001-2014.